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ABSTRACT

This paper reports the preliminary results of an experiment on the impact of computer assisted instruction (CAI) on disadvantaged students participating in the U.S. Department of Labor's Job Corps Program. In 1980-81, data were collected from participants in the Job Corps Comprehensive Computer Program at a large center in the Southwest. The program established separate experimental and control groups in basic skills reading and mathematics. The experimental group used regular Job Corps paper-and-pencil materials supplemented by CAI, while the control group used paper-and-pencil materials exclusively. All participants in the study were assessed as needing remedial work. Analysis of the pretest and posttest performance data for reading indicates substantially greater gains by participants in the CAI model, as compared to the control group. Associated with this gain were a shorter mean length of stay in Job Corps for students in the experimental group, as well as a lower dropout rate. No significant model effects in performance were found in mathematics. Some of the study's methodological problems that may have biased its results are discussed throughout the paper. (CG)

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THE IMPACT OF COMPUTER-ASSISTED INSTRUCTION ON DISADVANTAGED YOUNG ADULTS IN A NON-TRADITIONAL EDUCATIONAL ENVIRONMENT

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OVERVIEW

Computers represent a promising instructional resource in elementary and secondary education. Some research suggests that computer-assisted instruction (CAI) may be especially stimulative for educationally disadvantaged students who have performed poorly in traditional school programs. The great potential of CAI has resulted in a dramatic increase in the number of computers in schools. In Spring 1982 there were over 120,000 computers used for instruction in elementary and secondary public schools, triple the number in Fall 1980; approximately 96,000 (80 percent) of these were microcomputers. Currently, about 27,500 or 34 percent of the nation's public schools have one or more computers available for instruction (National Center for Education Statistics, 1982).

This paper reports the preliminary results of an experiment on the impact of CAI on disadvantaged students in a non-traditional educational setting, the U.S. Department of Labor's Job Corps Program. Job Corps began to introduce computers into its curriculum as part of an educational improvement effort in 1978. This evaluation of their effectiveness is based on an experimental-control group study conducted at one Job Corps Center.

There have been a number of similar experimental evaluations on the impact of computers on instruction in recent years. Since the use of computers in schools is a relatively new phenomenon, additional studies are important to establish a credible resource base upon which to make policy decisions concerning CAI. This experiment also makes a unique contribution to the literature since it varies from most existing studies in several ways. First, the majority of research on CAI has been conducted in traditional educational settings: elementary schools, secondary schools, community colleges, and four year colleges. This analysis assesses the impact of CAI in a non-traditional educational environment. Second, unlike most traditional educational programs, Job Corps uses individualized, self-paced instructional programs which can be readily adapted to CAI. In Job Corps' CAI programs, individualized computer lessons are prescribed for each student based on personal learning needs and the student is allowed to proceed through the lessons at his or her own speed. Third, in this evaluation the educational delivery mode is varied (computer versus paper-and-pencil) but the instructional approach remains constant (individualized

and self-paced), allowing the real effects of the computer to be assessed. In most evaluations of CAI, comparisons are typically made between different instructional approaches as well as different delivery modes (Orlansky and String, 1979). For example, a conventional classroom-oriented lecture and text approach is often compared to a computer-oriented individualized, self-paced approach.[1] This type of comparison presents problems because it is difficult to determine the relative contributions of instructional approach and delivery mode.

DESCRIPTION OF THE JOB CORPS PROGRAM

The Job Corps program grew out of a commitment in the early and mid 1960s to intervene against some of the many sources of poverty. Its initial objective, revealed in its name, was to provide disadvantaged youth with vocational and related training to enable them to obtain and keep jobs. Over the years, Job Corps has expanded and adapted to serve disadvantaged youths whose needs have not been met by traditional educational systems. Today, Job Corps can be described as an alternative educational environment providing vocational training, education, and pre-employment and life skills. There are now 107 Job Corps centers serving nearly 40,000 youth between 16 and 22 years of age at any one time. Several of the largest centers have capacities up to 2,600 students.

Job Corps was designed to meet the needs of enrollees within a reasonable period of time. By law, the maximum period of enrollment is two years. The average length of stay in the program is six to seven to months. New enrollees enter centers on a weekly basis (Job Corps is an open-entry, open-exit program) and are placed in educational, pre-employment, and vocational curricula. In education, all students are given screening and/or placement tests in reading and mathematics to determine their instructional needs. The large majority of students need remediation and instruction in basic skills, although some students enter a GED

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1 Most instructional programs using CAI are, at least in part, individualized and self-paced. Not all assign students to a particular courseware package based on individual needs as in Job Corps. However, at a minimum, the computer will usually provide individualized responses and prompts based on student choice of an alternative or answer. Since students progress through the lesson at their own speeds, by nature CAI is self-paced.

preparation program which leads to a high school equivalency degree recognized by the state of residence.

Job Corps is unique in other features as well. The majority of the centers are residential. Enrollees live with their peers in dormitories and all of their basic needs--food, shelter, and health care--are provided. However, many of the centers added in recent years are located in urban areas, and some of their enrollees do not live on the center. All participants are provided with a weekly spending allowance and a separate clothing allowance. As an incentive to remain in the program, the weekly allowance increases over time. Nevertheless, Job Corps is a voluntary program and corpsmembers may leave when they wish, which means that the program must meet their needs in order to retain enrollees.

The Job Corps population is economically and educationally disadvantaged. All participants must meet established criteria of economic need. The following demographic profiles summarize Job Corps participants in 1981-82:

- Mean highest school grade completed before dropping out of school is approximately tenth grade.
- Mean reading and mathematics level at program entry is equivalent to about a sixth grade education.
- Typical enrollees have been out of school almost 1 1/2 years before entering Job Corps.
- Mean age is about 18.
- Sixty-eight percent of participants are male.
- Fifty-three percent of participants are black, 30 percent white, 90 percent Hispanic, and the balance mainly Asian and Native American.
- About 50 percent of participants come from cities with populations over 250,000.

DESCRIPTION OF THE JOB CORPS CAI PROGRAM

The CAI program evaluated in this experiment was called the Comprehensive Computer Program by Job Corps. It consisted of three main computer-based components:

- University of Illinois' on-line PLATO lessons
- Courseware adapted from the Minnesota Educational Computing Consortium driven by a minicomputer
- Courseware adapted from the Portland, Oregon Public Schools driven by a minicomputer.

This program was instituted on an experimental basis only at one large Job Corps Center in the Southwest. Subsequently, additional experimental programs using microcomputers and other minicomputer driven courseware were begun at other Job Corps centers. Only the Comprehensive Computer Program is included in this analysis.

The Comprehensive Computer Program established separate experimental and control models in basic skills reading and basic skills mathematics. Students in the experimental groups used regular Job Corps paper-and-pencil materials supplemented by CAI. The computer stimulus was used in addition to, not as substitute for, the regular program. Students in the control groups utilized regular Job Corps paper-and-pencil materials exclusively. In the experimental groups, up to one-third of a student's time was spent using computer-based materials. Of the time on the computer, about 75 to 85 percent was spent with University of Illinois' on-line PLATO courseware and the balance on the various minicomputer driven courseware. In both reading and math there were wide variations in the proportion of computer time used by individual students. The impact of these variations are discussed later.

Assignment to experimental and control groups was intended to be on a random basis. However, this Job Corps Center's scheduling system assigned all students in one vocational cluster to the same class. Therefore, random assignment by student was not possible without disrupting existing administrative procedures. Assignment by vocational cluster resulted in some disparities in the demographic

characteristics between experimental and control groups. As a result, statistical controls are used in the analysis to account for differences between groups. These controls are explained in a later section.

The Comprehensive Computer Program was implemented in 1981 and continues today. Data for this analysis were collected at various intervals during 1981 and 1982.

RELATED RESEARCH

While computers can never replace the effectiveness of teacher and student interaction, they offer many potential benefits as a teaching and administrative tool. For example, computers:

- Provide consistent instructional quality (O'Neil and Paris, 1981)
- Are always available and accessible
- Can be programmed to be patient, tolerant, and encouraging
- Permit individualized, self-paced instruction
- Give immediate feedback
- Can monitor student progress and offer diagnostic/prescriptive assessments.

Proponents of using CAI also suggest that computers offer all students a chance to be more active in the learning process. Students must interact with the computer frequently during the lessons. Research suggests that this interaction, along with the increased individualization that computerized instruction fosters, may reduce the amount of time needed to acquire specific skills and knowledge with no loss in retention.

Several good reviews of the literature on the educational impact of CAI have been completed. In a fairly early and comprehensive review, Edwards and colleagues (1974, 1975) concluded that computers were generally effective in substantially increasing achievement when used as a supplement to, but not as a substitute for, traditional instruction. However, CAI generally was not superior

when compared to other non-traditional instructional modes. Another review of the same time period (Jamison, Suppes, and Wells, 1974) reached many similar conclusions. In a more recent review, Thomas (1979) confirmed these earlier conclusions and provided additional evidence in several important areas. He concluded that:

- Learning time with CAI is reduced.
- The rate of retention with CAI does not differ from that found with other instructional modes.
- Students respond favorably to CAI.
- CAI can be cost-effective.

Chambers and Sprecher (1980) reviewed what they considered to be the most prominent CAI studies. Three of the four studies examined involved computers at the college level. The fourth, the vast Chicago City Schools Project which is now more than 10 years old and included data on over 12,000 fourth through eighth graders when reviewed by Chambers and Sprecher, has demonstrated some major achievement gains. The Chicago students were served by 850 terminals providing tutorial lessons in mathematics and reading. The average increase in reading ability by students using the computerized tutorial approach significantly surpassed that of student using paper-and-pencil materials. The final evaluation of this project should provide even more definitive results.

A number of research efforts on CAI deal exclusively with the computer's impact on economically and/or educationally disadvantaged populations. For example, Hirschbuhl, Myers, and Hirschbuhl (1980) examined the impact of CAI on seventh and eighth grade students in a remedial reading program. In ten minutes of CAI a day, this group averaged two months' growth for every month in the program. The non-CAI control group averaged only 1.4 months of growth per month. During the several years that this experiment was repeated, the CAI remedial reading group always scored a growth rate of at least .5 months greater than the control group. Similar results were found in mathematics.

Among other studies of educationally and/or economically disadvantaged populations, Romero (1980) found that below average students using CAI materials

gained significantly more than a control group. Modisett (1980) studied the remedial effects of CAI compared to paper-and-pencil workbooks on high school students and found that the former led to increased computational skill. Wells, Whelchel, and Jamison (1974) reported that achievement gains for economically disadvantaged minority fifth and sixth graders using CAI were one-third higher than a comparable control group not using CAI. Lysiak, Wallace, and Evans (1976) found greater gains for CAI users at the middle school level in Title I schools. In a non-experimental design, Maser, Johnson, and Davis (1979) found that their modest objective for second through ninth grade disadvantaged students in basic skills of one month of gain for each month of program participation was reached. Wilkinson (1979) reported that standardized achievement scores were significantly higher for CAI users from a low socio-economic community. These and other similar studies prompted Chambers and Sprecher (1980) to write that there were indications that low aptitude students profited more from the use of CAI than average or high aptitude students.

In summary, current research reports many favorable findings on the impact of computers in education in general and on disadvantaged populations in particular. However, this body of research must be interpreted cautiously. This is because the typical study has dealt with limited CAI programs in terms of both the populations served and the skill areas investigated and has not utilized well-designed and controlled evaluation components (Chambers and Sprecher, 1980). Some of the typical flaws of experimental design--lack of randomization, poor controls, insufficient length of treatment, experimental bias, and questionable statistical analysis procedures--have plagued this research (Ragsdale, 1978). Overall, the impact of computers on education, based on existing literature, can best be described as promising.

PROBLEMS AND LIMITATIONS OF THE RESEARCH

A number of problems plagued the execution of this experiment. Many of these are representative of the kinds of difficulties typically faced by social scientists using experimental designs in educational environments. First, because of budget limitations, the research team had to depend on the educational institution, in this case the Job Corps Center, to administer much of the study, including all

testing. Although detailed management instructions were developed and on-site monitors were employed on a part-time basis, some administative problems occurred. Of particular importance was the inability to posttest all program participants according tc the predetermined schedule. Coupled with program dropouts, this resulted in disparities in the size of both experimental and control groups between the number of students enrolled in the program and the number of students with posttest results upon program completion. In addition, the center was less rigorous in pretesting students in control groups than experimental groups, apparently because of the larger control group population. As a result, disparities exist between the sizes of the control group and experimental group samples.

Second, as mentioned earlier, problems occurred during attempted random assignment to experimental and control groups. The assignment of all students in a particular vocational cluster to the same class prohibited pure random assignment by student and resulted in demographic inconsistencies between experimental and control groups. These differences were ultimately controlled for using a less optimal alternative, statistical techniques.

Third, an unanticipated Department of Labor mandated cutback in Job Corps enrollment reduced the overall sample size. Job Corps centers were ordered in 1982 to hold enrollments at 94 percent of their projected levels. Since this cutback was not ordered until just prior to the fourth quarter of the fiscal year, new enrollments were drastically reduced and, for some weeks, stopped entirely. This period coincided with one of the heaviest periods of intended data collection.

Fourth, sample size was also reduced because of an interruption in project funding from the Department of Labor. Project funds were withheld for approximately six months in the middle of the experiment while the Administration reviewed Labor's annual budget. During this disruption, data on students entering and leaving the program could not be collected.

Fifth, the data collection monitors failed to consistently report which reading teacher was assigned to each participating student. Since this resulted in serious missing data, this variable was ultimately dropped from the analysis in the reading models. Its significance is that a teacher's background, teaching philosophy, and personality may affect student performance. Therefore, it is not possible to say

that the only differences between experimental and control groups are exclusively attributable to the computer stimulus rather than the individual teacher in reading.

Finally, the results of this analysis must be interpreted very carefully. Computers may have differential impacts based on such factors as:

- Student ability level
- Grade level
- Student background
- Extent of teacher training in computer use
- Subject area
- The mix between CAI and paper-and-pencil materials
- The particular courseware package or combination of packages being used
- Amount of time spent on the computer by the student
- Whether computers are placed in a resource room or in the classroom

Therefore, the results of this study may not be generalizable to other student populations.

METHODOLOGY

Shortly after arriving at the Job Corps Center, new students were given a series of tests, including short screening tests in reading and mathematics that were specially designed for Job Corps. On the basis of these test results, students were placed in an instructional level suitable for their ability. All participants included in this study were assessed as needing remedial work in the basic skills. This group consists of the overwhelming majority of Job Corps students. Students who have mastered the basic skills in reading or mathematics were excluded from this study. They enter a separately designed program in General Educational Development (GED) preparation, a high school equivalency program.[2] Students who have no

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2 CAI was also introduced on an experimental basis at the GED level. However, problems in its implementation preclude its reporting for research purposes.

English language reading skills or those who test below a certain cut-off point (approximately second grade) on the Job Corps reading screening test were placed in a separate beginning reading program which also was not included in this study. There was no minimum cut-off point in mathematics.

As previously described, students were assigned to the experimental or control group in reading or mathematics according to their vocational cluster,[3] a less than desirable practice from a methodological point of view. They were given the pretest for this study as soon as practical after assignment to the class, and always within one week of entry. The typical participant had five hours of instruction per week in each of reading and mathematics.

Participants in experimental and control groups in reading and mathematics were pretested with the primary or intermediate level of the Stanford Achievement Test (SAT), as determined by their score on the Job Corps screening test. Only one part of the SAT, Reading Comprehension for participants in the reading groups and Computation for participants in the mathematics groups, was used in each case. After 45 hours of instruction or upon completion of the program, whichever came first, students were posttested using an alternate form of the SAT. For those students who scored high on the primary pretest and had made appreciable progress according to the teacher, the intermediate level was used as a posttest. Since progress was measured according to the grade equivalency levels to which the raw scores on these tests were converted, this posed no measurement problems. A second posttest was scheduled after 90 instructional hours for students still remaining in the program.[4]

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3 All Job Corps students simultaneously begin educational remediation and vocational training immediately upon arrival.

4 The number of students taking a second posttest was limited by two factors. First, many students completed the basic skills program near the time of the first posttest and needed no further posttesting. Second, a very small number of students, who entered the program during its final months and completed a first posttest just before the close of data collection activities was mandated and still needed remediation, could not be tracked.

Educators accustomed tc traditional educational settings may find these intervals between pretest and posttest short. However, these intervals were motivated by two features of Job Corps. First, progress in individualized instruction in the basic skills programs has been fast (nearly one grade level in reading in 45-50 hours of instruction according to the results of an earlier assessment of progress using paper-and-pencil materials only). Second, Job Corps is a voluntary program. There is nothing to prevent students from simply walking out and using their weekly allowance for a bus ticket home. Even with this schedule, many students could not be posttested because they left Job Corps without notice.

The major dependent variable for both reading and mathematics was gain from pretest to posttest in grade equivalent levels. This served as the strongest measure of the relative effectiveness of the experimental and control groups. An additional possible basis of comparison between experimental and control models was dropout rate. It would be misleading to use dropout rate exclusively as a basis of comparison between models, since many of the factors contributing tc it are not related to educational policy. Nevertheless, to the extent that accurate data are available, differences in the dropout rate between models are reported.

As previously indicated, limitations in the implementation of the program compromised some of the criteria for experimental design. In order to assure comparability between experimental and control groups, a linear multiple regression analysis with covariates was performed. This procedure permits statistical adjustments for any observed unequal contributions of selected variables used as covariates.

Selection of possible covariates for the analyses was guided by both known relationships in the sample based on previous work with this population and theoretical predictive relationships consistent with existing educational literature. The literature suggests that certain educational, demographic, or socio-economic characteristics may be determinants of educational performance. In order to reduce problems of multicollinearity, correlation coefficients between selected covariates were examined with one of a pair of highly correlated variables chosen for exclusion. Those variables finally selected for inclusion as covariates were model

(experimental versus control), ethnic group (black, white, Hispanic, other), sex, highest grade completed in school (6th or less, 7th, 8th, 9th, 10th, 11th, 12th), months out of school before entering Job Corps, pretest grade equivalent level, hours of instruction at time of posttest, and teacher (available for mathematics classes only).[5] It was hypothesized that greater educational gains would be attained by participants using CAI-supplemented instruction than those in the control model, assuming equivalent characteristics and levels for all other independent variables.

RESULTS AND DISCUSSION

Reading

A profile of the students enrolled in the CAI and control models in reading is shown in Table 1. Some of the differences between the two groups (notably in distribution by sex, mean months out of school, and mean grade equivalent level on the reading screening test) were due to the clustered assignment to the two models. These unequal effects were adjusted for statistically.

More potentially troubling is the gap between the number of students pretested for each model and the number who have completed one or more posttests. In both models there was serious unexplained attrition. Attrition was somewhat less severe (52.7%) in the CAI model than the control model (62.7%). Some possible explanations for this early attrition can be made by examining status in the model for each participant. These figures are shown in Table 2.

These figures reveal that only minimal percentages of students were still actively enrolled in the model but had not yet reached the number of hours for posttesting at the completion of data collection. Students not posttested are

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5 No interaction effects were included. It is recognized that this probably reduced the variance accounted for by the regression equations. However, the goal of the study was limited to comparisons between two educational models, rather than a complete analysis of the predictors of educational attainment. Given the methodological constraints imposed on the study, it was decided to concentrate only on the central objective.

TABLE 1

ENROLLMENT PROFILE IN READING MODELS

	CAI	CONTROL
Number Enrolled	659	150
Number Posttested	312	56
Ethnic Group		
Black	63%	71%
Hispanic	18%	16%
White	18%	11%
Other*	1%	1%
Sex		
Male	78%	40%
Female	22%	60%
Mean Age	18.1	18.3
Mean Highest Grade Completed	9.8	9.9
Mean Months Out of School	14.9	16.2
Mean Grade Equivalent Level on Reading Screening Test	6.3	5.4

* This category includes Native Americans, Asian Americans, and others.

TABLE 2

STATUS FOR READING STUDENTS WITHOUT POSTTESTS BY MODEL

	CAI	CONTROL
Completed Model	43%	42%
Active in Model	4%	2%
Withdrew from Model	53%	56%

divided into two large groups: those who withdrew from the model largely because of premature termination from Job Corps and those who were program completers despite the absence of posttests. The latter category is disconcerting because it represents apparently lost data. A check of model and center procedures provides three possible explanations. First, some students completed the program in fewer than 45 hours and monitors were not informed of the fact or were unable to locate them by the time they became aware of it. Second, some data, especially during the early shakedown period of the models, were not recorded properly. Third, some students could not complete the model after having enrolled in it because of extensive damage to the CAI facilities during a tornado in the first phase of the program. Unfortunately, there is no way of determining the relative contribution of any one explanation. We are left with the reality that some data are simply not available. Fortunately, these lapses seem equally balanced between the CAI and control models.

A summary of findings for all students who have completed the CAI and control models is presented in Table 3. According to these data, there appear to have been substantially greater gains by participants in the CAI model compared to those in the control model. Associated with this was a shorter mean length of stay in Job Corps for participants in the CAI model and a lower dropout rate, as measured by terminations from model before completion. These differences in educational attainment between participants in the CAI model and those in the control model were achieved with approximately 33 percent of total instructional time spent on the computer.

The greater gain from pretest to first posttest in the CAI model compared to the control model was confirmed in the regression analysis of covariance. The overall regression equation approached significance $R = .295$, $F(14,250) = 1.70$, $p = .056$, although only 8.7% of the variance was accounted for by the variables included in the equation. When the data were adjusted for the covariates, significant model effects emerged $F(1,250) = 6.11$, $p = .014$. The predicted or adjusted gain for the experimental model was 1.36 grade equivalent levels compared to .35 grade levels for the control group. The only other independent variable to show significant differences when adjusted for all covariates was pretest $F(1,250) = 14.12$, $p = .0002$, indicating that pretest grade level, like model, is an excellent

TABLE 3

READING GAINS AND STATISTICS BY MODEL

Students with 1st Posttest	CAI	CONTROL
Number Posttested	312	56
Mean Pretest Grade Level	6.0	5.2
Mean Posttest Grade Level	7.4	6.1
Mean Grade Levels Gained	1.4	.9
Mean Hours of Instruction	49	48
Students with 1st and 2nd Posttests		
Number Posttested	92	14
Mean Pretest Grade Level	5.5	4.6
Mean 1st Posttest Grade Level	6.6	5.4
Mean 2nd Posttest Grade Level	7.0	5.4
Mean Grade Levels Gained to 1st Posttest	1.1	.8
Mean Grade Levels Gained to 2nd Posttest	1.5	.8
Mean Hours of Instruction	95	*
All Students		
Mean Length of Stay in Job Corps (Days)	185	239
Dropout Rate	25%	42%

*Not available for most of sample.

predictor of posttest performance. There were no significant effects for any of the other independent variables: ethnic group, sex, highest grade completed in school, months out of school, and hours in model at time of post-test. The major results of the regression analysis are shown in Table 4.

There were not a sufficient number of completers of the second posttest in the control group to perform an analysis of covariance on these data. It is, however, interesting to note that students who progressed to a second posttest had lower pretest scores than those who took only the first posttest. This seems to be an indication that those who need more remedial work remain in the models longer. It should also be noted that students in the CAI model showed greater gains to the second posttest than those in the control model. Furthermore, only corpsmembers in the experimental model showed any gain from first posttest to second posttest. These differences should be interpreted with caution because of the small numbers with second posttests in the control group.

Perhaps the most important conclusion from these results is that the greater gains of participants in the CAI model put them at a mean grade level (7.4) that is appropriate for advancement into GED preparation after an average of only 49 hours of instruction. Even those students with greater remedial needs, as evidenced by their lower pretests and the presence of a second posttest, were close to the GED level at completion. This group showed a mean grade level of 7.0 after 95 hours of instruction.

Mathematics

The mathematics program implementation, like that in reading, resulted in imbalances between the CAI and control groups. Here they were in ethnic group and mathematics ability on the Job Corps screening test. A profile of participants in both models is shown in Table 5.

There is also a problem in attrition from pretest enrollment to posttest. This attrition is more serious in the control group (74%) than the CAI group (57.4%). Unfortunately, efforts to explain these differences by investigating model status

TABLE 4

RESULTS OF REGRESSION ANALYSIS ON GAIN TO FIRST POSTTEST IN READING

Source	df	Sum of Squares	F	p	R
Explained	14	10571.49	1.70	.056	.295
Error	250	111080.72			
Total	264	121652.20			

COVARIATES

		Unadjusted Effects			Adjusted Effects		
Source	df	Sum of Squares	F	p	Sum of Squares	F	p
Model	1	1319.99	2.97	.086	2715.21	6.11	.014
Ethnic Group	3	362.38	.27	.846	646.22	.48	.697
Sex	1	168.84	.38	.538	119.82	.27	.604
Highest Grade Completed	6	1800.57	.68	.670	2643.43	.99	.432
Hours at Posttest	1	109.63	.25	.620	663.77	1.49	.223
Months Out of School	1	536.32	1.21	.273	712.29	1.60	.207
Pretest	1	6273.76	14.12	.0002	6273.76	14.12	.0002

TABLE 5

ENROLLMENT PROFILE IN MATHEMATICS MODELS

	CAI	CONTROL
Number Enrolled	601	319
Number Posttested	256	83
Ethnic Group		
Black	61%	62%
Hispanic	19%	15%
White	18%	8%
Other*	2%	15%
Sex		
Male	78%	77%
Female	22%	23%
Mean Age	18.2	18.0
Mean Highest Grade Completed	9.7	9.4
Mean Months Out of School	14.4	17.4
Mean Score on Mathematics Screening Test**	54.5	40.1

* This category includes Native Americans, Asian Americans, and others. It is predominantly Indochinese refugees in the control model.

** This test has no grade level equivalents. The maximum possible score is 100.

show different patterns for both the CAI and control models. Table 6 shows that a much smaller percentage of those not posttested completed the model in the control group, while a much larger percentage withdrew from the model and Job Corps.

As in reading, the first category is most disturbing, because it suggests irretrievably lost data. The reasons for this missing data are the same as those postulated for the reading models. The greater level of withdrawal from the model for the control group compared to the CAI group is puzzling. Given the variety of factors that influence the decision to drop out, no difference in this category would be expected. Together, these divergent patterns between the CAI and control models indicate some differences between those remaining in the study that cannot be readily adjusted. Thus, drawing meaningful conclusions from the comparisons between the two mathematics models may be difficult.

The major findings for students in the CAI and control models are presented in Table 7. These data show that although achievement diffferences existed between the two groups on entry, amount of gain was virtually the same for both models to the time of the first posttest. Corpsmembers in both models also showed similar patterns of gain to the time of the second posttest for those corpsmembers progressing to that point.

The regression analysis of covariance performed on the mathematics data for corpsmembers with first posttests only confirms the lack of differences between models. While the overall regression equation was significant $R = .527$, $F(16,111) = 2.67$, $p = .001$, and accounted for 27.8 percent of the variance, the model effects were so small after adjustment for the covariates that no estimates were possible. Thus, there was no basis on which to statistically differentiate between the models. The only independent variables to show significant effects were hours of instruction $F(1,111) = 9.47$, $p = .0026$ and pretest $F(1,111)$ 12.31, $p = .007$, indicating their strong predictive effect on gain. There were no significant differences as a function of ethnic group, sex, highest grade completed in school, months out of school, and teacher. The results of the regression analysis are shown in Table 8.

TABLE 6

STATUS FOR MATHEMATICS STUDENTS WITHOUT POSTTESTS BY MODEL

	CAI	CONTROL
Completed Model	59%	32%
Active in Model	6%	2%
Withdrew from Model	34%	65%

TABLE 7

MATHEMATICS GAINS AND STATISTICS BY MODEL

Students with 1st Posttest	CAI	CONTROL
Number Posttested	256	83
Mean Pretest Grade Level	6.4	5.0
Mean Posttest Grade Level	7.2	5.8
Mean Grade Levels Gained	.8	.8
Mean Hours of Instruction	62	53
Students with 1st and 2nd Posttests		
Number Posttested	71	18
Mean Pretest Grade Level	5.4	3.7
Mean 1st Posttest Grade Level	6.2	4.8
Mean 2nd Posttest Grade Level	7.0	5.0
Mean Grade Levels Gained to 1st Posttest	.8	1.1
Mean Grade Levels Gained to 2nd Posttest	1.6	1.3
Mean Hours of Instruction	*	*
All Students		
Mean Length of Stay in Job Corps (Days)	185	252
Dropout Rate	24%	65%

*Not available for most of sample.

TABLE 8

RESULTS OF REGRESSION ANALYSIS ON GAIN TO FIRST POSTTEST IN MATHEMATICS

Source	df	Sum of Squares	F	p	R
Explained	16	15363.86	2.67	.001	.278
Error	111	39923.75			
Total	127	55287.62			

COVARIATES

		Unadjusted Effects			Adjusted Effects		
Source	df	Sum of Squares	F	p	Sum of Squares	F	p
Model	1	2981.73	8.29	.005	.00	.00	-
Ethnic Group	3	1001.19	.93	.432	1102.10	1.02	.387
Sex	1	425.57	1.18	.279	1.49	.00	.949
Highest Grade Completed	6	2372.32	1.10	.367	2766.89	1.28	.271
Teacher	2	574.98	.80	.452	63.88	.09	.915
Hours at Posttest	1	3568.11	9.92	.002	3404.82	9.47	.003
Months Out of School	1	13.99	.04	.844	3.46	.01	.922
Pretest	1	4425.98	12.31	.001	4425.98	12.31	.001

It is difficult to explain why there were no significant model effects in mathematics but were in reading. One explanation may lie in the nature of the materials utilized or their presentaiton. Another may lie in the suitability of the materials for CAI. However, these seem unlikely in view of research on the effectiveness of CAI, which has often been reported as most successful in mathematics. Students in this CAI model spent an average of only 23 percent of their total time in the model on the computer. Thus, it may be that the proportion of time spent on the computer was not sufficient to realize its educational benefits.

The number of students with a second posttest was too small in the control group to permit an analysis of covariance. The data for this group in both models show that it was composed of those who began the program with lower pretest scores and thus had the greatest need for continued study. Due to the vastly different pretest and first posttest levels between the CAI and control models and the small numbers with second posttests in the control group model, interpretation of these data is difficult.

CONCLUSION

The results of this study on the effectiveness of CAI compared to an individualized control group yield some mixed but promising findings. Most promising is the existence of significant differences in gain in reading between the experimental and control groups. Mean gain in reading was one full grade equivalent level higher for students supplementing their instruction with CAI than for students not receiving supplementary CAI. This gain was adjusted for the effects of a number of covariates including hours of instruction, sex, ethnic group, pretest grade equivalent level, and two measures related to previous schooling. There were a number of potentially serious problems which could have threatened the validity of these results for the reading models. However, these were distributed similarly among students in both models. Any other observed differences between the participants in the models before the treatment were statistically adjusted for in the regression model with covariates.

The results in mathematics were less encouraging. There were major differences in the measured attrition of enrolled students between the experimental

and control groups. The findings were based on posttests available, but there was no basis on which to adjust for the differences between the models in likely reasons for lack of a posttest. Adjustments in the regression model using available covariates failed to identify any differences in gain between students using supplementary CAI and those not using it. However, it is difficult to determine whether this lack of difference is due to acceptance of the null hypothesis or uncorrectable differences between the models in attrition.

It is interesting to note that participants in the experimental group in both reading and mathematics had a much lower dropout rate than the controls. This may suggest that students showed greater interest in the CAI models. Also, participants in the CAI model had a shorter mean length of stay in Job Corps. Coupled with the lower dropout rate, this last finding may indicate that participants in the CAI model obtained the benefits of Job Corps in a shorter period of time.

Notwithstanding the methodological limitations of the results of the mathematics models, the external validity of the stronger results in reading must be addressed. In any study, generalizability of results is based upon comparability of populations. In studies involving the effectiveness of a new technology with a unique content there are also other cautions which must be considered in the interpretation of the results. Positive findings may be due, in part, to the novelty of computer technology or to a Hawthorne-type effect. Additionally, gains found may be likely to fade over time. These possible alternative explanations do not take away from the strength of the findings on the effectiveness of CAI in reading. Rather, they point out that many more studies, in a variety of populations, are needed before the final word on CAI is available. However, when considered in the context of the brief review of CAI literature reported in this paper, these findings provide some additional substantive evidence on the greater effectiveness of CAI in one learning area.

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